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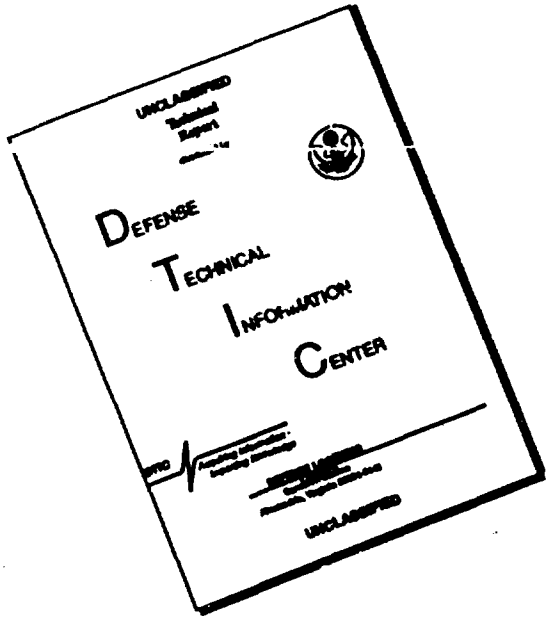


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# A CASE STUDY OF BACTERIAL LEAF BLIGHT OF WETLAND RICE

Nogyo oyobi engei
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Cases of bacterial leaf blight of wetland rice and resulting crop damage have been reported from various parts of the country from year to year. With respect to this particular disease, there have been reports from Nakada and Ishiyama, and also the Aichi, Kumamoto, Saga, and other Agricultural Experimental Stations which have clarified to some extent our knowledge concerning the pathogen, the circumstances of occurrence of the disease, methods of control, and which have also contributed to the development of resistant strains. The Kogyoku and Koganemaru strains developed by the Aichi Prefectural Agricultural Experimental Station are known to be particularly disease resistant, and these varieties have been recommended to farmers in various prefectures.

In 1949, there was an epidemic of bacterial leaf blight in Aichi Prefecture with the disease occurring as early as late July in some parts and the disease developing so rapidly such that the terminal leaf was observed to be infected when the ear was being formed. Under such circumstances, it is necessary to make a detailed on-the-spot investigation of the crop damage incurred, to inact emergency measures, and to study the growth of disease resistant varieties, improved methods of cultivation, and permanent measures for control of the disease.

Based on this viewpoint, several actual surveys were conducted in the vicinity of Togo village in the county of Minamisetsuraku. The survey was generally conducted on the basis of different river systems. Within a group of lands of a water system, individual paddies were studied. We further investigated the relation between the rice variety and disease occurrance ...

also the relation between disease occurrence and the method of cultivation. This report includes the results of field investigation conducted on and around September 10 and October 20.

1. Relief and soils of southern part of Minami-setsuraku County.

The topography of the land which was investigated consisted of the ridges of the Gaho Mountains, running east-west, located to the north of the area, and the south being bounded by the Toyo-kawa (river). The area between the mountains and the river was a diluvial terrance, most of it being farmed. There were numerous streams of 6 to 12 feet width originating in the mountains, forming a pectinated pattern draining the terrace, with each of these stream systems irrigating narrow to wide bands of terraced wet paddies, and the systems being separated by dry farmland. Small dams were appropriately located on these streams to provide irrigation water for the associated wet paddies of the system.

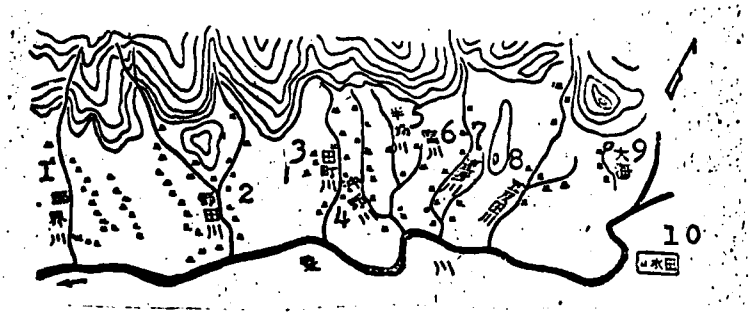


Figure 1. Relief map of southern part of Minami-setsuraku-gun. Legend: (1) Gunka-gawa. (2) Noda-gawa. (3) Tamachi-gawa. (4) Nakano-gawa. (5) Hanba-gawa. (6) Miya-kawa. (7) Rengo-gawa. (8) Gotanda-gawa. (9) Taikai. (10) Wet paddy.

The soil was a mixture of acid soils containing gneiss, granite particles, and humus (See Figure 1).

Area investigated

The area investigated consisted of the rice paddies irrigated by the tributaries draining into the Toyo-kawa (river) contained in the political subdivisions Togo-mura (village), Shinjo-machi (town), and Sengo-mura (village), the investigation being conducted according to individual tributaries. The names of these streams and adjoining localities are as follows:

| | |
|---|---|
| Taikaitameikegakari | Taikai |
| Gotanda-gawa | [illegible] → Yasoichiro → [illegible] |
| Rengo-gawa | Sunaga → Yasoichiro → [illegible] → Kamaji |
| Miya-kawa | Ushigura → Cmiya → Tomisawa → Kamaji |
| Hanba-gawa | Ushikura, Yabe, Tominaga → Tomizawa |
| Okino-gawa | Kamihirai → Hirai → Tomizawa |
| Tamachi-gawa | Katayama → Togo, Sengo-mura boundary<br>Hirai → Nishihirai-machi |
| Noda-gawa | Tokusada, Usuko → Hoei → Suwa → Noda<br>Nakashijo |
| Gunkai-gawa | Kawada |

2. Incidence of disease by area

The area studied was known for its high incidence of bacterial leaf blight of the rice plant in past years, and in 1949, infection of the second and third leaves was noticed as early as late July, with the disease spreading very rapidly. It was noticed that within the area, there were variations in the incidence of the disease, and this prompted our attention to investigate this area.

Between September 9 and 11, the situation concerning bacterial leaf blight infection in the entire basins of nine streams was investigated, attention being paid to differences between river systems as well as to the location of the rice paddies within a basin. According to the results summarized in Table 1, it can be seen that seven of the nine river systems had bacterial leaf blight, also that there were differences between the river systems with respect to severity of the disease, also that infection in the upper and middle reaches of the river systems generally meant that there was progressively severe infection of rice plants also in the lower reaches of these rivers. It was also noted that the distance between the Taikai system, which was uninfected, and the Gotanda system, one of the infected systems, was only a few hundred yards. It can be concluded from these results that the distribution of bacterial leaf blight infection is somehow related to the irrigation system.

3. Investigation of individual rice paddies in a particular infected area.

The Matsuda sector in the Okino-gawa basin, where the disease was particularly rampant, was selected for a detailed paddy-to-paddy survey from October 19 to 21. The survey was mainly in the localities of Ichinomichi, Takahashi, Matsuda, and Banba, with no infection observed in the upper reaches of the river.

Table 1. Incidence of bacterial leaf blight disease by river system

| Name of river | Bacterial leaf blight disease | | |
|---|---|---|---|
| | Degree | Location | Name of Locality |
| Taikaitameikegakari | None | | |
| Gotanda-gawa | Slight | Midstream | Yasokucho |
| Rengo-gawa | Severe | From midstream | Takahiro, Komaji |
| Miya-kawa | Severe | From upstream | Ushikura, Tomiyaga, Tomizawa |
| Hanba-gawa | Moderate | From downstream | Tomizawa |
| Okino-gawa | Severe | From midstream | Kamihirai, Hirai |
| Tamachi-gawa | Severe | From midstream | Hirai, Nishiaraimachi |
| Noda-gawa | Slight | Downstream | Nakashijo |
| Gunkai-gawa | None | | |

Bacterial leaf blight of the rice plant generally started with infection of the lower leaves, with the infection moving to the upper leaves such that by October 20, the extent of the disease could be judged by observation of infection of the terminal leaf. The severity of the disease was judged according to the following criteria:

(1) Infection of only the lower leaves with no infection of the terminal leaf.

(2) Slight infection of the terminal leaf.

(3) Infection of 1/3 of the terminal leaf.

(4) Infection of 1/2 of the terminal leaf.

(5) Infection of 2/3 of the terminal leaf.

(6) Infection of the entire terminal leaf.

As can be seen from Figure 2, the disease was found in all of the rice paddies of the area investigated without expection. Similar to the situation in the other river basins, there was less indicence of the disease upstream towards Ichinomichi but progressively severe infection downstream. At the same time, there were differences between individual rice paddies in the degree of infection with bacterial leaf blight.

Within a single paddy, there was also variation in the degree of infection, and there was also variation with time. That is to say, in the early stages of infection around late July to early August, severest infection was found among plants located near the water intake of the paddy, with scattered infection of other plants in the same paddy.

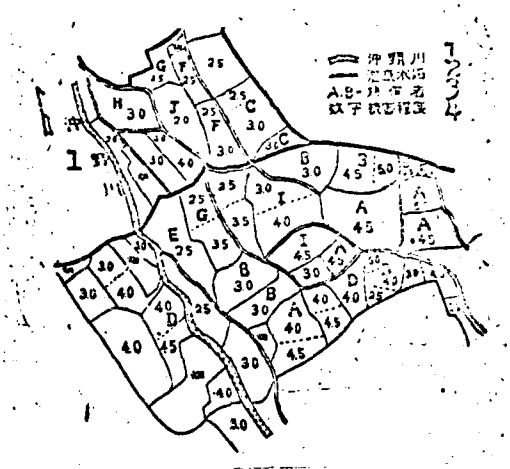

Figure 2. Incidence of disease in Masuda area.
Legend: (1) Okino-gawa. (2) Irrigation ditch. (3) Identification of farmer. (4) Figures indicate degree of severity of disease.

The scattered infection is assumed to be due to infection in the seed beds prior to transplanting to the main paddy, while the infection of plants near the water intake is assumed to be a primary infection.

With growth of the rice plant, the pattern of infection in a single rice paddy changes, that is to say, the initially severe infection near the water intake is no longer serious. When a water channel is established along one side of the paddy, infection is clearly lighter along such a channel, and this seems to mean that the colder water experienced near the water intake and in such a water channel tends to inhibit development of the disease.

4. Degree of infection and variety of rice plant.

In the Matsuda area, the Aichi-asahi variety of rice is predominantly grown, with other varieties such as Tokai-asahi, Hashushimo, Koganemaru, and indigenous mochigome being cultivated in insignificant quantities. The effect of variety on infection

to the disease was studied with respect to these varieties.

In the survey of September 10, all five varieties were observed to be equally infected, the degree of infection amounting to total covering of the fourth and fifth leaves with lesions, some lesions on the second leaf, and occasional lesions on the terminal leaf.

In the survey of October 20, Aichi-asahi, Tokai-asahi, and Hatsushimo were found to be heavily infected, while Koganemaru and indigenous mochigome were found to be relatively lightly affected by the disease. From a distance, amidst the greyish-white fading of the former three varieties could be seen the golden ripening ears of plants of the varieties Koganemaru and indigenous mochigome.

5. Relation between method of cultivation and infection.

In order to establish a relation between the method of cultivation and the incidence of the disease, the authors embarked on interviews with the farmers, but due to important unknown factors such as the amount of fertilizer used, this method of approach was dropped, and we conducted studies of the practices of individual farmers with respect to the degree of infection, the relation between the seedbed and the main paddy, and the relation between irrigation and fertilization practices and incidence of the disease.

(1) Incidence of disease by individual farmer.

According to Table 2, it can be seen that by individual farmer in the Matsuda area, there are some differences in the incidence of the disease related to the method of cultivation.

Table 2. Incidence of disease by farmer.

第2表 耕作者単位の罹病状態

| 1 耕作者 | 2 品種名 | 苗代 | 6 本田 | | | | | | | | 7 備考 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 愛知旭 | 4.5 | 4.0 | 4.0 | 4.0 | 4.5 | 4.6 | 4.5 | 5.0 | | |
| B | 〃 | 3.0 | 3.0 | 3.0 | 4.5 | — | — | — | | | |
| C | 〃 | 2.5 | 2.5 | 3.0 | — | — | — | — | | | |
| D | 〃 | 4.0 | 3.0 | 4.0 | 4.0 | 4.0 | 4.5 | 5.0 | — | | |
| E | 〃 | 0 | 2.5 | 2.5 | 2.5 | — | — | — | — | | 無病地に苗代設置 8 |
| F | 〃 | 2.5 | 2.5 | 3.0 | — | — | — | — | | | |
| G | 〃 | 0 | 2.5 | 2.5 | 3.0 | — | — | — | — | | 無病地に苗代設置 8 |
| H | 〃 | 3.0 | 3.0 | — | — | — | — | — | | | |
| I | 4 〃 | 4.0 | 3.0 | 4.0 | 4.0 | — | — | — | | | |
| J | 黄金丸 | 0 | 1.5 | 2.0 | — | — | — | — | — | | 無病地に苗代設置 8 |

Legend: (1) Identification of farmer. (2) Variety of rice. (3) Aichi-asahi. (4) Koganemaru. (5) Incidence in seedbed. (6) Incidence in main paddy. (7) Remarks. (8) Seedbed established in uninfected land.

(2) Difference in incidence of disease between seedbed and main paddy.

In Figure 3 is shown the relation between the incidence of disease in the seedbed after transplanting and the incidence of disease in the main paddy. It can be seen that where infection is high in the seedbed, there is also a high degree of infection in the main paddy. Considering the cases of farmers E and G listed in Table 2, whose seedbeds are both located upstream in the same river basin on uninfected land, the infection of rice plants in the main paddies of these farmers is found to be considerably less than in the paddies of farmers with diseased seedbeds. It can be seen that diseased seedbeds result in primary infection and subsequently a larger degree of infection in the main paddy, while shoots from uninfected seedbeds transplanted into diseased paddies will incur secondary infection but with less disastrous results than in the former case.

(3) Management of irrigation and other elements.

In the area investigated, there was one farmer who tended to be negligent in fertilization practice, with irrigation water being allowed to flow constantly through his fields. The growth of rice plants in his fields naturally tended to be poor, but surprisingly, there was very little disease. One of the factors responsible for this result is no doubt the effect of the water temperature, as once previously described.

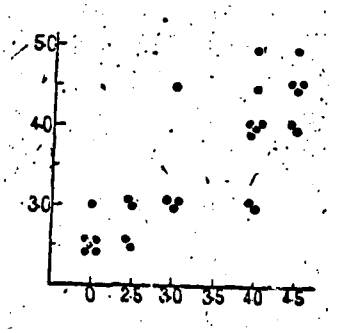


Figure 3. Relation between seedbed after transplanting and the main paddy with respect to incidence of disease.

6. Relation between bacterial leaf blight disease and the number of kernels per ear, number of unripened kernels, and weight of grain.

In order to establish a relation between infection of the terminal leaf and grain yield of the plant, we studied, mainly

with respect to the Aichi-asahi variety of rice grown in the Matsuda sector, the weight of an ear, the number of kernels per ear, the number of unripened kernels, and the weight of a thousand kernels.

Although we were not able to investigate the yield in this survey, the loss of weight of ear and kernel and the increase in the number of unripened kernels were sufficient indicators of the deleterious effect of the disease on the yield.

From among the individual rice paddies which were studied in detail as previously described, 14 were selected, ranging from light to heavy infection, and from each of these paddies, 15 plants with the best ear growth were sampled, the results being shown in Table 3 and Table 4.

Table 3. Relation between bacterial leaf blight of the rice plant and number of kernels per ear, number of unripened kernels, and weight of grain.

第3表　白葉枯病と1穂粒，不稔粒，粒重との関係

| 1 病徴による被害程度 | 2 品種名 | 耕作者 | 6 1穂重 | 7 1穂粒数 | 8 不稔粒数 | 9 不稔粒歩合 | 10 千粒重 |
|---|---|---|---|---|---|---|---|
| | | | g | | | % | g |
| 1.5 | 3 黄金丸 | J | 2.5 | 89 | 12 | 13.5 | 29.8 |
| 2.0 | 〃 | J | 2.5 | 83 | 10 | 11.2 | 29.6 |
| 3.0 | 4 愛知旭 | I | 2.9 | 113 | 16 | 14.0 | 28.9 |
| 3.0 | 〃 | C | 2.8 | 99 | 13 | 13.0 | 29.0 |
| 3.0 | 〃 | B | 3.1 | 111 | 14 | 13.0 | 30.0 |
| 4.0 | 〃 | D | 2.6 | 97 | 13 | 13.4 | 28.9 |
| 4.0 | 〃 | D | 2.5 | 92 | 13 | 14.4 | 29.2 |
| 4.0 | 〃 | I | 2.6 | 100 | 13 | 13.0 | 29.3 |
| 4.5 | 〃 | A | 2.4 | 99 | 23 | 23.0 | 28.2 |
| 4.5 | 〃 | A | 2.5 | 91 | 15 | 17.0 | 28.4 |
| 4.5 | 〃 | A | 2.5 | 103 | 22 | 21.4 | 27.9 |
| 5.0 | 〃 | A | 2.5 | 105 | 21 | 20.0 | 27.3 |
| 5.0 | 〃 | B | 2.4 | 101 | 24 | 24.0 | 26.8 |
| 5.0 | 〃 | D | 2.5 | 117 | 33 | 25.0 | 26.9 |

11 (備考) 15株に就き最長穂の穂を調査平均する

Legend: (1) Degree of damage (visual observation). (2) Variety of rice. (3) Koganemaru. (4) Aichi-asahi. (5) Identification of farmer. (6) Weight of an ear. (7) Number of kernels per ear. (8) Number of unripened kernels. (9) Percentage of unripened kernels. (10) Weight of 1000 kernels of grain. (11) Remarks: Average of fifteen plants with largest spikes.

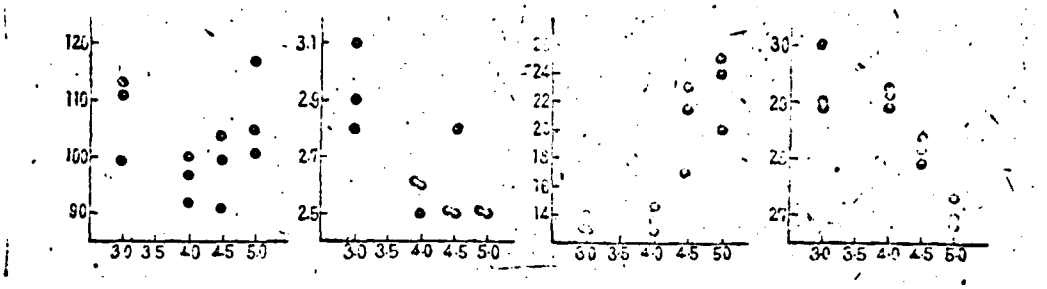


Figure 4. Relation between bacterial leaf blight disease and ripened seed.

The results clearly show that with the severity of the disease, there is a decrease in the weight of an ear and the weight of a kernel of grain accompanied by an increase in the percentage of unripened grain, while there is almost no change in the number of kernels per ear. The numberof kernels per ear is usually not affected by the disease, since this number is determined early in the growth of the plant, while infection of the plant generally occurs much later, retarding growth and assimilation of nutrition and resulting in lighter weight of the fruit.

In our conversations with the farmers during the investigation, it was found that the disease was usually severe in years of drought with inadequate irrigation water, also that the disease usually flared up with depletion of fertilizer in the soil. These observations contradict the results of previously run tests, and it is difficult to provide a satisfactory explanation in this case.

## 7. Conclusion

Although this investigation only covered a small area, the results obtained were as follows:

The incidence of bacterial leaf blight of the rice plant is closely related to the associated water system. In the case of diseased water systems, there is always infection of plants downstream in the system. There are examples of nearby but different water systems with similar conditions, where no blight is found. The study shows that, considering the characteristics of the bacteria, transmission of the disease is mainly through the seed, straw, or the water system, and that once infection occurs, the disease is propagated downstream by the irrigation

water. Although there are differences in the severity of the disease, infection is generally widespread, the method of cultivation has some influence on the degree of infection, and in the cases where primary infection occurs in the seedbed, the damage from the disease in the main paddy is also quite severe. Variety plays an important role in resistance to the disease. In the case of the variety, Reganokuro, a resistant variety, the nature of the infection is similar to [illegible] in the early stages of growth, but with the passage of time, the disease resistant variety proves [illegible]. There is a definite relation between the severity of the disease and the factors directly related to yield, and the disease is capable to cause a great reduction in yield.

Although the area surveyed was annually attacked by blight to a serious degree, the farmers of this area were found to be rather nonchalant about the situation, accepting the dying out of the plants in a greyish-white color as normal without the adoption of any specialy control measures. The reasons Reganokuro, a resistant strain, is not grown in this heavily infected area are the low yield and the late maturity of this variety, while the Aichi-asahi, a susceptible variety is favored for its fairly high yield.

As previously related in the description of the topography of this area, the streams in this area erode the land such that river beds are deep, the paddies form terraces on both banks, and there are apt to be frequent shortages of irrigation water. Although there are very few low-water paddies, most of the paddies are two-crop rice paddies. The Matsuda area surveyed is typical of this type of rice farmland, that is to say, although none of the paddies are ever fully covered with water during the entire growing season, there is nevertheless an overall incidence of the disease. Some of the dryland rice grown on the adjoining terraces is also seen to be infected with bacterial leaf blight. Generally flooding of the rice paddies with water is considered to be the primary cause of bacterial leaf blight infection, but in the case of this area, where the disease is prevalent, the cause must exist in the ordinary flowing-irrigation water. Since winter wheat is grown on the paddies, diseased straw is left in the fields to further infect and even worsen the disease distuation in the coming years.

More recently, farmers have expressed a growing interest on the subject of disease resistant varieties, and although various control measures are being studied, by far the most effective means of control is the development and the use of disease resistant varieties.